CHAPTER 3

Deep-Draft Ships

3-1. Introduction. Merchant ships used in worldwide and domestic commerce vary in size, hull design, and maneuverability, depending on commodities handled, ocean trading region, ports being served, and channels and waterways used. Investments by shipowners to build new and larger ships are heavily influenced by anticipated profit margins from future shipping revenues. Several worldwide economic factors have a direct bearing on ship investment decisions, including:

a. *Anticipated increase in shipping demand.*

b. *Competition among the various nations in world trade.*

c. *Potential for increased efficiency.*

d. *Need to replace obsolete ships.*

e. *Outlook for world oil production.*

Considerable effort is expended by shipowners and their naval architect designers in optimizing ship characteristics to account for economic parameters, port limitations, and operating costs that will provide adequate revenue from anticipated freight rates. Ships are designed for open- water, deep-sea conditions at full sea speed; this type of normal operation determines ship profit-making capabilities. Thus, ship maneuverability at slow, harbor speeds is a secondary attribute.

3-2. Ship Characteristics.

a. The general trend toward increased economic advantage of larger ship sizes continues and is especially important for bulk cargo ships and containerships. Many tankers in the world petroleum fleet cannot be accommodated in U.S. ports, which in most cases have controlling depths of 12.2 m (40 ft). Other bulk carriers with coal, ore, or grain cargoes include many ships with design drafts greater than 12.2 m. Containerships up to 14.3 m (47 ft) design draft are in service. Most general cargo ships, on the other hand, are usually designed for maximum draft of 12.2 m (40 ft), and do not normally play an important role in the design depths of many navigation projects. Bulk carriers and containerships have been the usual project design ship for increased navigation channel depths. Most studies concerned with development or improvement of deep-draft channels involve the economic analysis of larger ships or greater loads in ships using the existing project.

b. The largest ships in service are Ultra Large Crude Carrier (ULCC) tankers up to about 550,000 deadweight tons (dwt); this size ship is usually used in dedicated trade routes, such as from the Persian Gulf, around the Cape of Good Hope, and to offshore ports to serve Europe. Ships of this size have drafts approaching 30.5 m (100 ft) and can enter none of the major world ports. Indications are that maximum bulk carrier ship sizes will get no larger, but the average ship capacity will gradually increase as older ships are retired from service. Bulk carriers and tankers up to about 55,000 dwt can call at ports with 12.2-m (40-ft) channel depths; deepening to 15.2 m

(50 ft) will provide access to 105,000-dwt ships. Lightering operations and light-loaded tankers of this size do use existing 12.2-m (40-ft) channels.

3-3. Ship Dimensions.

a. Ships are complex three-dimensional (3-D) bodies whose sizes are described by several geometric parameters that are important to channel design and port operations. The navigation designer should be aware of the main ship geometry parameters and the important dimensions normally used, especially as they relate to commodity loading capacity and design ship parameters. The three principal ship dimensions are length, beam, and draft. The definitions of the various ship lengths used are presented in Figure 3-1; a similar drawing describing ship beam and draft appears in Figure 3-2. The ship depth and freeboard are two additional dimensions important in design and cargo capacity. Definitions of the more important geometric parameters are given in the Glossary.

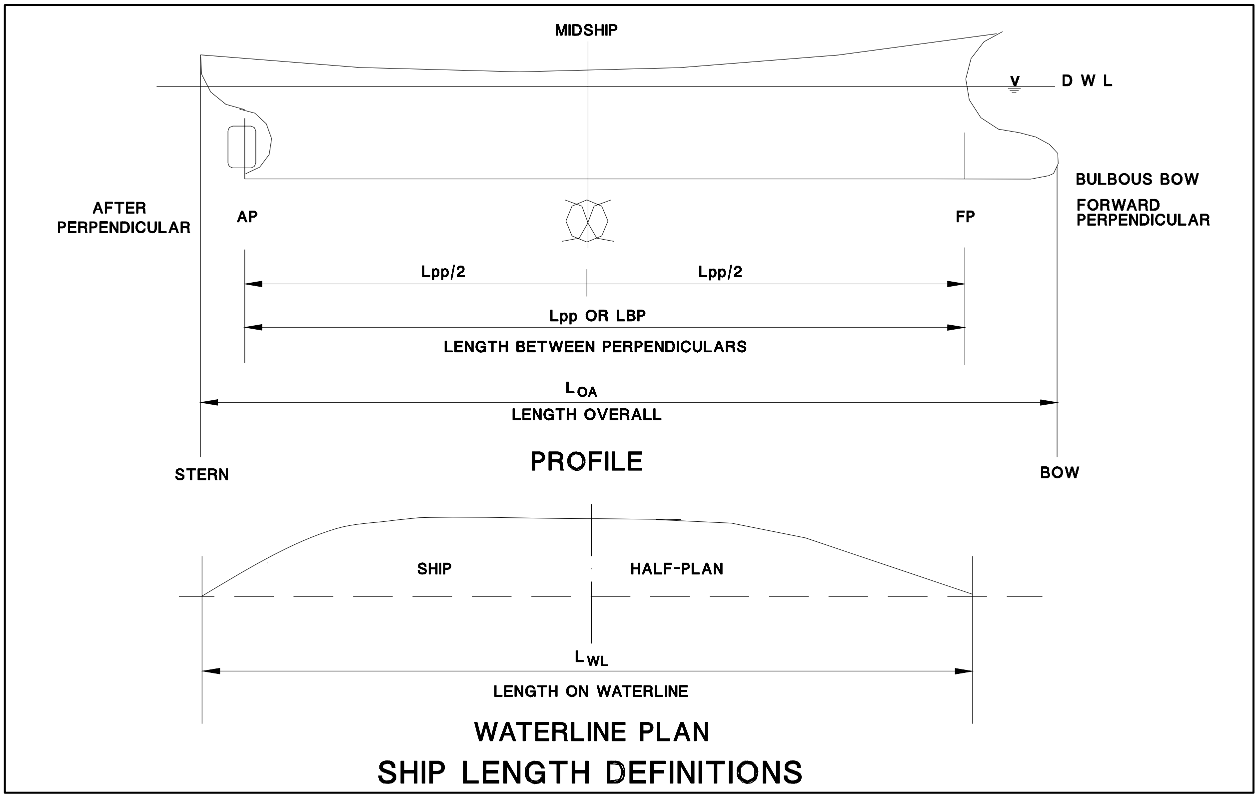


Figure 3-1. Ship length definitions

b. The most important length is the length between perpendiculars (Figure 3-1) since this governs ship cargo capacity and hydrodynamics. The length overall is the distance from the extremity of the bow structure to the stern structure. Another length on the ship design waterline may also be listed. The ship molded beam is the maximum ship width to the outer edges of the ship hull structural members at the maximum ship cross section, which is usually at the ship waterline, amidships. The maximum ship hull width is equal to the molded beam plus the hull plating thickness on each side of the ship. The beam at the design waterline may also be less than the maximum (Figure 3-2).

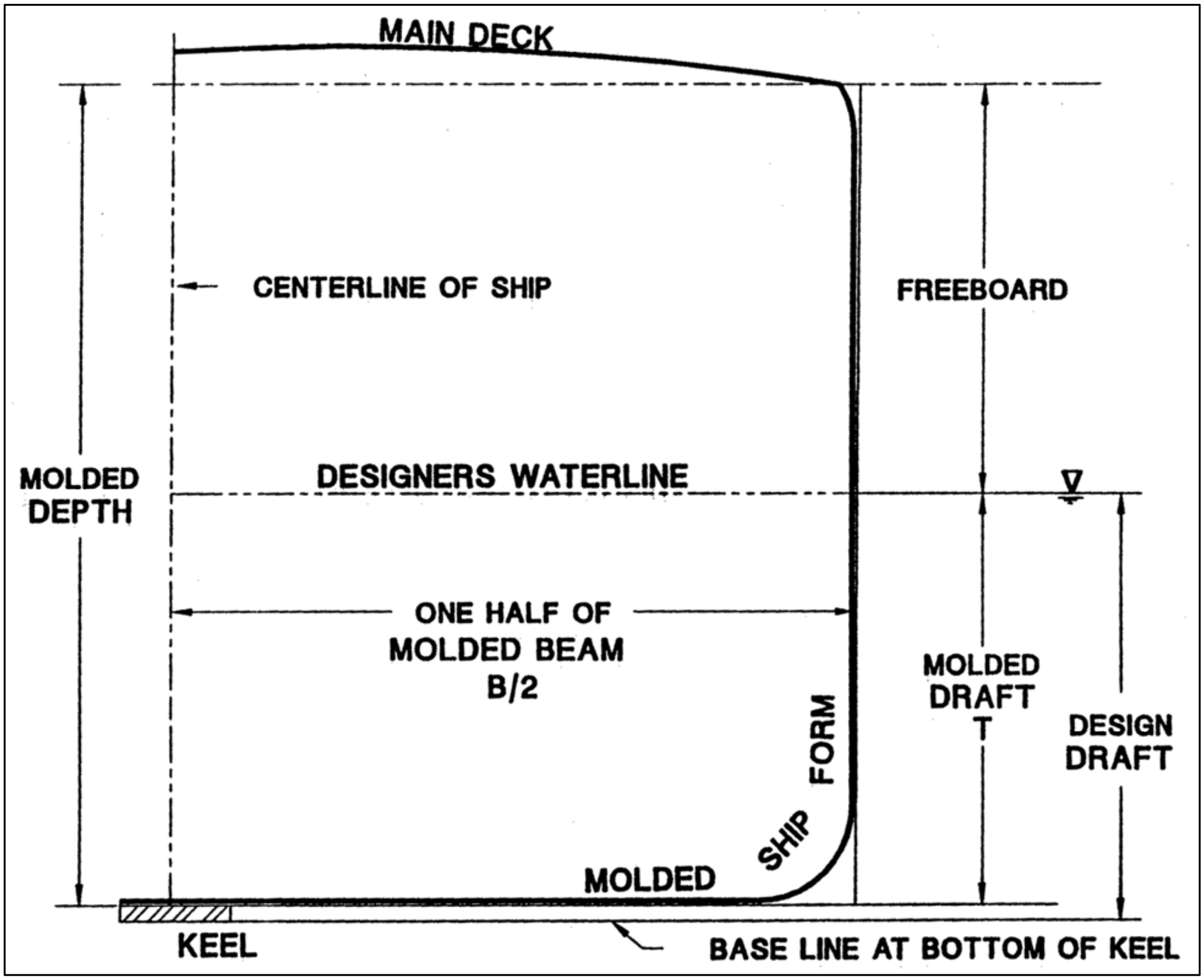


Figure 3-2. Midship-section molded-form definitions

c. The ship draft is the molded design or service ship draft and is the vertical height from the waterline to the inside edge of the hull structural members. The design waterline draft adds the keel thickness to the molded draft; usually, this is equal to the summer load line assignment draft certified by international convention and as authorized by the local rating society. The markings on the ship sides conform to the load line assignment. Ships in service are often loaded to less than the maximum draft, referred to as partially laden draft. A ship in ballast is loaded to ballasted draft. The forward draft and after draft are the ship drafts at the bow and stern, respectively; the average is the mean draft. Another ship dimension often provided in ship data lists is given as the ship depth; care must taken that this dimension not be confused with the ship draft. The freeboard is the difference between the ship depth and the draft and is usually an amount mandated by the load line assigning authority.

3-4. Cargo Capacity. The cargo-carrying capacity of a ship by weight is the dwt. However, this value also includes the weight of fuel, oil, fresh water, stores, crew, and baggage. The dwt is a reliable commodity capacity measure for tankers and most bulk carriers. Containerships are rated by Total Equivalent Units (TEU's), which are based on the number of 6.1-m (20-ft) boxes the ship can carry. The standard size box is 6.1 m long and 2.4 m (8 ft) wide by 8 ft deep. Containership box lengths may also include dimensions of 3.0, 6.1, 9.1 or 12.2 m (10, 20, 30, or 40 ft). Some bulk carriers with light cargo at high stowage factors (termed high cubic by the trade), such as grain or wood chips, may be more appropriately rated in volume. The standard naval architect's seawater specific or unit volume (reciprocal weight density) of 0.000976 m^3/kg @ 20 °C (35 ft^3/long ton) may be used to convert from weight to volume capacity. The capacity of LNG ships is also given in volume: cubic meters. Some ships may carry cargo with material density less than water's (e.g., wood chips), resulting in full volume loads with drafts less than design draft. The latter circumstances would impact channel design if the economic justification of channel depth were based on the design draft.

a. The loaded weight displacement of a ship is the total weight of the floating ship at its greatest allowable (fully loaded or design) draft. The difference in weight displacement between the loaded and unloaded ship condition is the dead weight; thus, the dead weight is equal to the loaded displacement minus the light displacement. The density of water can be used to convert weight displacement, Δ, to volume displacement, ∇. In this conversion, care must be given to the proper density value with respect to fluid salinity and temperature.

b. Ship so-called tonnage characteristics may sometimes be encountered during navigation channel planning and design. These are often given as gross and net tonnage and are only poorly related to ship cargo-carrying capacity. The tonnage of these ship characteristics is not really in tons at all, but the units are in 3.121 cu m per ton (100 cu ft per "ton") and to be used strictly for the purpose of setting canal tolls and port fees.

3-5. Form Coefficients.

a. A multitude of ratios and dimensionless coefficients are used by naval architects to describe ship hull form proportions and often used in ship design. The following discussion focuses on the two most useful form coefficients that the navigation analyst may need. One of the most commonly used is the block coefficient (C_B) which is used to describe the ship "fullness" or "fineness." It is the ratio of the volume of displacement to the volume of the rectangular block having the appropriate main ship dimensions, as shown in Figure 3-3.

$$C_B = \frac{\nabla}{LBT} \tag{3-1}$$

where

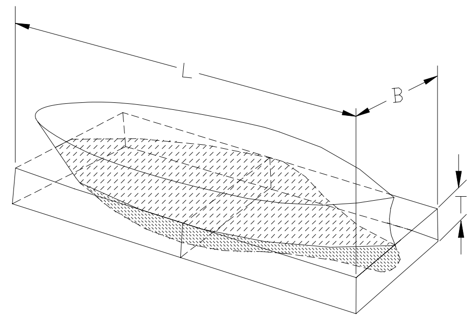
∇ = volume of displacement at molded draft T in cubic meters (cubic feet)

L = ship length between perpendiculars in meters (feet)

B = ship molded beam at the maximum section area in meters (feet)

T = ship full load molded draft in meters (feet)

The block coefficient for commercial ships varies from about 0.50 for fine form ships such as cargo liners and containerships up to about 0.90 for very full tankers and bulk carriers.



Block coefficient definition

Block coefficient (C_B) = Ratio of the volume of displacement to the volume of a rectangular block having a length, beam, and draft equal to that of the ship.

$$C_B = \frac{\nabla}{LBT}$$

L = Length between perpendiculars

T = Draft to the designed waterline, or molded ship draft

B = Beam amidships at the designed waterline, or molded beam

∇ = Volume of displacement of molded ship form at draft T

Figure 3-3. Block coefficient definition

b. Another coefficient used to describe ship performance is called the slenderness ratio. The one-third power is used to keep the ratio dimensionless.

$$C_s = \frac{L}{\nabla^{1/3}} \tag{3-2}$$

Values of this ratio vary from about 4.0 to 10.0 with increasing ship fineness. Figure 3-4 graphically indicates the empirical relationship between the block coefficient and the ship length Froude number for typical commercial vessels. A fitted curve is shown through the data points. This figure shows that ships with higher speeds tend to be "fine lined" or less "blocky," i.e., have a lower block coefficient.

c. Ship dimension ratios are also very important in describing ship behavior, such as maneuverability. The length-to-beam, length-to-draft, length-to-depth, and beam-to-draft ratios are the most commonly used. Common values for these ratios for various ships and smaller vessels are shown in Table 3-1, which summarizes typical data.

3-6. Restrictions. Canal and lock sizes have an important effect on ship design, and the navigation analyst should be aware of those limitations. The Panama Canal has the following size limits because of the locks, which define Panamax ships allowed to transit the canal

a. Draft of 12.0 m (39.5 ft) fresh water, less in the dry season.

b. Beam of 32.2 m (105.75 ft).

c. Length of 289.6 m (950.0 ft).

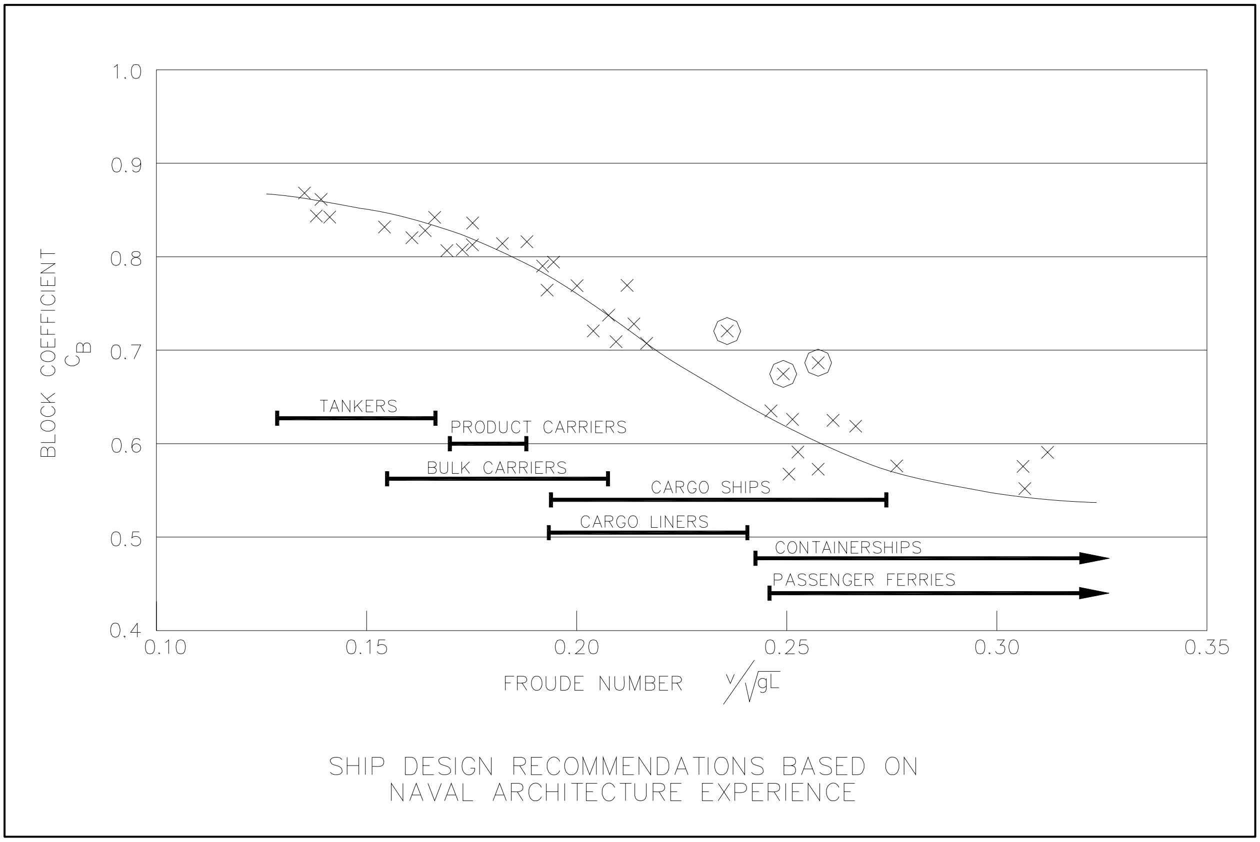


Figure 3-4. Ship design recommendations

The Suez Canal has no locks, but ships are limited to 16.2 m (53.0 ft) in draft and 64.0 m (210 ft) in beam; there are no limits on ship length. Large bulk carriers use the canal in ballast.

3-7. Ship Speed. The speed at which the design ship will be operated in the proposed channel should be selected carefully. The engine setting is changed from sea speed to maneuvering speed when a ship approaches a harbor area. This usually limits the maximum engine revolutions per minute (rpm) to less than the service speed available in the open ocean. Operational considerations also limit ship speeds because of the need to reduce ship squat (Chapter 6, paragraphs 6-6 to 6-13), increased ship resistance (Chapter 4, paragraph 4-4), and vessel wake and wave effects on waterways (Chapter 4, paragraphs 4-5 and 4-6). Ship speeds are also governed by ship control needs where wind, currents, and waves would tend to reduce the control margins. There is no doubt that there is also some economic incentive to keep vessel speeds at the highest prudent level, especially for projects with long transit distances or where tidal advantage is being exploited. An important consideration is the minimum ship speed necessary to maintain adequate ship steerage; this is normally 4 or more knots above the water current. Transit speeds from 5 to 10 knots are the most common ship speed in typical harbor channels as observed on a number of projects.

Table 3-1
General Typical Ship Hull Form Coefficients

Type	C_B	L/B	B/T	Speed V, knots, ft/sec	Length Froude No.[1] $F_l = \frac{V}{\sqrt{gL}}$	Number of Propellers/ Rudders	Rudder Area Ratio[2]
Harbor tug	0.50	3.3	2.1	10 (16.8)	0.25	1/1	0.025
Tuna seiner	0.50	5.5	2.4	16 (26.9)	0.31	1/1	0.025
Car ferry	0.55	5.1	4.5	20 (33.6)	0.34	2/2	0.020
Container high speed	0.55	8.3	3.0	28.5 (47.9)	0.53	2/2	0.015
						2/1	0.025
Cargo liners	0.58	6.9	2.4	21 (35.3)	0.29	1/1	0.015
RO/RO[3]	0.59	6.9	3.0	22 (37.0)	0.26	1/1	0.015
Barge carrier	0.64	7.5	2.9	19 (31.9)	0.20	1/1	0.015
Container med. speed	0.70	7.1	2.8	22 (37.0)	0.25	1/1	0.015
Offshore supply	0.71	4.7	2.75	13 (21.8)	0.28	2/2	0.016
General cargo low speed	0.73	6.7	2.4	15 (25.2)	0.20	1/1	0.015
Lumber low speed	0.77	6.7	2.6	15 (25.2)	0.20	1/1	0.025
LNG (125,000 m^3)	0.78	6.8	3.7	20 (33.6)	0.20	1/1	0.015
OBO[4] (Panamax)	0.82	7.5	2.4	16 (26.9)	0.17	1/1	0.01
OBO (150,000 dwt)	0.85	6.4	2.4	15 (25.2)	0.15	1/1	0.017
OBO (300,000 dwt)	0.84	6.0	2.5	15 (25.2)	0.14	1/1	0.015
Tanker (Panamax)	0.83	7.1	2.4	15 (25.2)	0.16	1/1	0.015
Tanker (100,000 to 350,000 dwt)	0.84	6.2	2.4	16 (26.9)	0.15	1/1	0.015
Tanker (350,000 dwt)	0.86	5.7	2.8	16 (26.9)	0.13	1/1	0.015
U.S. river towboat	0.65	3.5	4.5	10 (16.8)	0.25	2/2	...

[1] $\frac{V}{\sqrt{gL}}$ where V = ship speed, ft/sec ; g = acceleration due to gravity, ft/sec^2; and L = ship length, ft. To convert feet to meters, multiply by 0.3048.
[2] RUDDER AREA/SHIP LENGTH * DRAFT
[3] Roll-on, roll-off type ships
[4] Oil-, Bulk-, Ore-type ships

3-8. Conventions. A number of international rules have been developed by the seafaring nations to govern ship design in the interest of safety. Toll and service charges in ports and through canals also have an impact on ship design. Insurance companies are very influential by their rate-setting formulas. All ships are required by the U.S. Coast Guard to obtain load line certificates, which satisfy minimum static stability standards and attest to the seaworthiness of the ship. The main effect of the conventions and rules is in devising minimum freeboard allowances for ships in various trade route services. This has a direct impact on cargo loading limitations by the ship owners. The load line markings on the sides of the ship are an embodiment of the ship loading limitation and provide a visual guide on allowable ship drafts. These are called the Plimsoll markings, as shown in Figure 3-5, and depict different ship operational conditions, including freshwater draft, summer seawater draft, etc.

3-9. Maneuverability.

a. The maneuverability of ships depends on many factors, some of which are controllable by the naval architect in the ship design process. Usually, however, the economics of ship operational costs in the open ocean dominate the design, which often results in poor-handling ships. The navigation channel designer should understand the main ship characteristics that determine maneuverability for proper assessment of required channel dimensions.

b. Ships underway with normal self-powered operations in harbors are controlled by propellers and rudders located at or near the ship stern. The engine size that turns the propeller(s) and rudder area are the two most important parameters determining maneuverability. Handling characteristics of ships with twin propellers and a single rudder not located in the propeller slipstreams are usually poor compared with twin propellers and twin rudders located in the slipstreams. Single-propeller, single-rudder designs with adequate size rudders in the slipstream can provide adequate maneuverability. The availability of bow and stern thrusters increases the maneuverability of ships, especially at low speeds. Generally, maneuvering ships through navigation channels tends to be more difficult as the size of ship increases. The design of tankers and bulk carriers often makes the vessel directionally unstable, inhibiting the turning ability and causing difficulties in halting the turning of the vessel (called yaw checking). Pilots frequently use bursts of power and rudder action to start a ship in a turning maneuver; thus, the kick-turn ability of a ship is an important factor in ship control. Care must be taken to control this operation so that the ship does not gain too much speed.

c. Control of a ship becomes especially crucial when speed is being reduced while stopping or approaching a position to attach tugs for maneuvering assistance. Most ships tend to lose rudder control when the ship speed approaches 4 knots. Because of engine design, some ships are very difficult to steer at 6 knots or less and thus are difficult to control. Prudent mariners usually reduce engine speed when approaching a channel turn or other anticipated situations requiring major maneuvers. Reversing ship engines will frequently cause reduction or possibly loss of ship control.

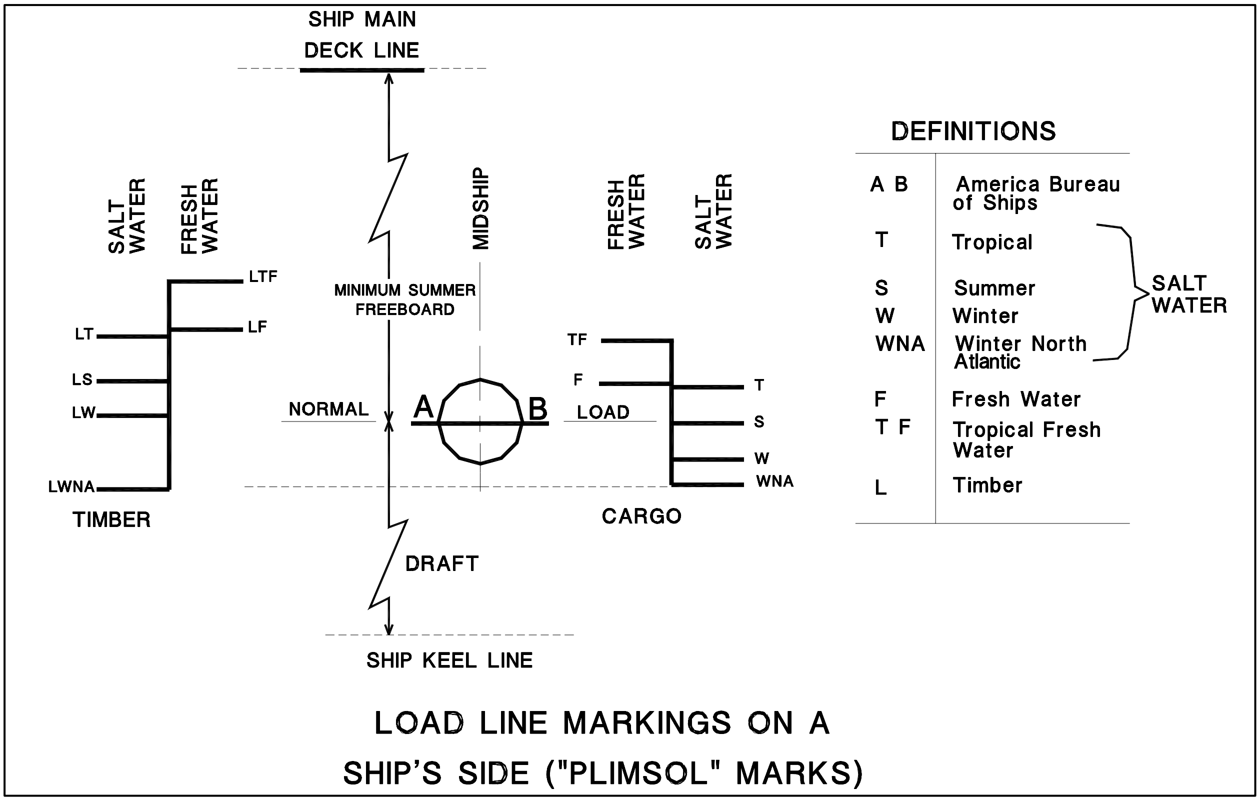


Figure 3-5. Load line markings on a ship

3-10. Environmental Factors.

a. The maneuverability of ships in a given navigation situation is influenced to a great degree by the environmental forces and resulting movements caused by the speed and direction of river and tidal currents, wind, waves, and channel banks. Studies have shown that ice at the surface and “fluff” on the channel bottom can also result in modified ship maneuverability. General rules to account for environmental factors are very difficult and usually are strongly site-specific.

b. Current and wind effects for normal operational levels are often not crucial, provided adequate ship speed can be maintained. Conversely, wave effects and bank suction forces will increase in severity with increasing ship speed. Bank suction is the term used to denote the forces and moments as a result of unequal pressure on a ship’s hull. The force on the hull is created when a ship transits off the channel centerline or when the banks are not symmetrical, thereby changing the flow pattern area between the hull and the submerged bank, accelerating the water and decreasing the dynamic pressure. Bank suction normally rotates the ship away from the bank because of the unsymmetrical pressure forces along the longitudinal axis of the hull. Current effects are much more important than wind effects, especially when currents have significant components perpendicular to navigation channels. In general, constant winds and currents pose less difficulty than time-varying or space-changing effects, which induce transient ship forces. Wind effects on ships are much more important for ballasted rather than loaded tankers because of the high above-water “sail area.” Car carriers and containerships with loaded boxes have substantial wind effects in many operations, especially at reduced speeds.

3-11. Design Ship.

a. The design ship or ships are selected on the basis of economic studies of the types and sizes of the ship fleet expected to use the proposed navigation channel over the project life. For project improvement studies, a thorough review and analysis of ships presently using the project should be included as a part of the study. Projections of ship fleet data, usually needed, account for expected ship construction trends. An example tabulation of merchant ships segregated into different categories by ship draft and cargo capacity in deadweight tons is presented in Table 3-2. This table shows that tankers and bulk carriers comprise the main ship types above Panamax draft of about 12.2 m (40 ft).

Table 3-2
Liquid Bulk Merchant Fleet of the World Categorized According to Draft Class
(To convert feet to meters, multiply by 0.3048)

Draft Class (ft)	Total Count	Total dwt	Total DWT Cumulative Percentage	Tankers		Product Tankers		LPG[1] Carriers		LNG[2] Carriers		Crude Oil Tankers		Chemical/Oil Tankers		Chemical Tankers	
				Count	Avg dwt	Count	Avg dwt	Count	Avg dwt	Count	Avg dwt	Count	Avg dwt	Count	Avg dwt	Count	Avg dwt
<10	295	1,612,207	0.5	166	3410	43	16,253	30	3902					13	6224	43	3472
10	140	319,473	0.6	58	1484	46	3649	8	1338					5	1212	23	2121
11	116	306,738	0.7	62	2678	28	3719	11	1038	1	463			3	1725	11	1774
12	147	286,470	0.8	93	2321	17	1995	19	720					6	1053	12	1392
13	279	419,481	0.9	134	1696	23	2415	69	971	3	992			9	1320	41	1337
14	333	542,653	1.1	170	1900	29	1545	66	1257					6	1571	62	1330
15	345	747,974	1.4	221	2247	27	2481	53	1839					11	2317	33	1862
16	303	727,593	1.6	190	2345	35	2896	38	2295			1	2000	7	2631	32	2283
17	312	910,151	1.9	159	2891	37	3064	62	3122					6	3165	48	2595
18	306	1,117,165	2.2	138	3582	31	4774	40	3452					16	3193	81	3527
19	268	1,009,730	2.6	154	3572	38	4012	46	4274			1	3395	9	3703	20	3693
20	231	1,048,847	2.9	95	4492	29	5408	24	5481	21	2692	1	4999	10	4270	51	4500
21	270	1,407,631	3.4	115	5092	38	5454	29	4954	1	9090	1	4999	27	4944	59	5484
22	277	1,639,346	3.9	112	5691	56	6446	29	4807			1	4986	22	6506	57	6201
23	250	1,982,690	4.5	67	6353	44	12,972	14	5881	2	10,979	2	17,500	21	6999	100	7000
24	137	1,095,598	4.9	39	7524	29	9897	17	5994			1	12,615	13	8100	38	7772
25	123	1,128,899	5.2	15	9998	21	10,825	21	6586	2	12,839			27	9096	37	9244
26	130	1,387,620	5.7	21	9900	40	13,387	8	7115					19	10,084	42	9422
27	87	990,191	6.0	11	11,542	13	12,198	20	11,062	1	21,301			16	11,740	26	10,549
28	101	1,507,759	6.5	17	16,629	23	16,390	19	8448	3	41,131			14	14,894	25	14,227
29	134	2,095,506	7.2	17	15,402	19	18,116	6	11,560			30	18,946	24	13,360	38	13,976
30	125	2,303,890	7.9	19	16,559	48	21,020	16	13,748	3	28,412			16	17,482	23	17,191
31	123	2,894,830	8.8	24	21,948	56	22,421	11	15,218	12	41,738	1	59,543	4	16,875	15	21,147
32	84	1,965,446	9.5	6	23,702	30	27,829	25	17,472					9	21,710	14	25,441
33	98	2,813,581	10.4	2	23,979	46	31,084	7	24,588	2	34,887	1	35,679	10	24,399	30	27,140
34	92	2,839,038	11.3	22	30,044	50	31,803	7	24,483	1	27,235			4	31,026	8	33,150
35	153	5,188,065	13.0	18	33,300	80	32,190	12	31,773	3	61,632	7	40,156	10	36,288	23	34,927
36	321	11,921,363	16.8	26	35,755	188	33,922	40	43,367	16	65,018	14	45,991	9	40,931	28	29,542
37	215	8,625,276	19.6	6	44,531	146	36,210	9	41,550	20	69,953	3	70,726	8	32,378	23	35,966
38	98	4,818,287	21.1	11	38,933	35	39,548	11	35,114	25	71,158	8	63,891	4	41,869	4	40,509
39	139	7,172,298	23.4	10	47,201	58	47,928	18	45,957	13	71,161	25	61,834	11	41,521	4	41,391
40	219	12,682,801	27.5	27	50,604	99	52,276	2	50,786	4	73,145	56	77,375	27	45,783	4	44,469
41	104	5,899,624	29.4	3	58,941	56	53,405	23	49,821	1	80,239	19	75,819	2	32,719		
42	126	8,520,599	32.1	10	76,452	49	56,472	6	50,191			58	78,395	3	46,965		
43	97	7,383,320	34.5	3	94,995	26	62,172	12	50,091			55	87,858			1	48,581
44	90	7,224,193	36.8	11	94,506	21	63,828	5	57,533	1	83,020	49	88,587	2	44,983	1	42,825
45	94	7,946,303	39.4	18	75,507	12	82,965	5	57,110			59	89,933				
46	60	5,529,881	41.2	8	87,285	7	77,664	1	43,386			43	97,152	1	67,031		
47	55	5,234,185	42.9	5	98,373	5	84,851					45	95,957				
48	51	5,422,759	44.6	3	95,193	5	106,634					43	107,070				
49	61	6,508,458	46.7	3	117,460	2	105,251					56	106,171				
50	35	4,301,177	48.1	1	141,861	3	99,515					31	124,541				
51	41	5,119,042	49.7	5	131,648	3	117,148					33	124,526				
52	5	562,011	49.9	2	156,522	2	82,658									1	83,651

(Continued)

Table 3-2 (Concluded)

Draft Class (ft)	Total Count	Total dwt	Total DWT Cumulative Percentage	Tankers Count	Tankers Avg dwt	Product Tankers Count	Product Tankers Avg dwt	LPG[1] Carriers Count	LPG[1] Carriers Avg dwt	LNG[2] Carriers Count	LNG[2] Carriers	Crude Oil Tankers	Crude Oil Tankers	Chemical/Oil Tankers	Chemical/Oil Tankers Count	Chemical Tankers Avg dwt	Chemical Tankers Count
53	43	5,437,336	51.7	2	132,578	12	83,885					29	143,640				
54	20	2,832,840	52.6									20	141,642				
55	79	10,810,995	56.0	3	140,193							76	136,716				
56	50	7,407,504	58.4	1	159,718							49	147,914				
57	21	3,125,661	59.4									21	148,841				
58	1	127,002	59.5									1	127,002				
59	6	824,153	59.7							1	70,593	5	150,712				
60	1	238,898	59.8									1	238,898				
61	5	735,225	60.0									5	147,045				
62	21	5,154,030	61.7									21	245,430				
63	27	6,932,061	63.9									27	256,743				
64	36	9,187,452	66.9									36	255,207				
65	28	6,935,824	69.1									28	247,708				
66	12	3,093,732	70.1									12	257,811				
67	34	9,535,606	73.2									34	280,459				
68	40	10,953,284	76.7			2	294,772					38	272,730				
69	38	10,665,992	80.1									38	280,684				
70	15	4,198,560	81.5									15	279,904				
71	25	7,200,575	83.8									25	288,023				
72	45	13,522,320	88.1									45	300,496				
73	52	16,894,280	93.6									52	324,890				
74	22	7,067,312	95.9	1	392,798							21	317,834				
75	17	6,261,321	97.9									17	368,313				
76	3	1,124,334	98.2									3	374,778				
77	1	409,400	98.4									1	409,400				
78	1	132,960	98.4									1	132,960				
79	1	491,120	98.6									1	491,120				
81	1	564,650	98.7									1	564,650				
82	4	1,830,252	99.3									4	457,563				
83	2	1,033,318	99.7									2	516,659				
93	1	484,276	99.8									1	484,276				
94	1	555,051	100.0									1	555,051				
TOTAL	7723	310,927,473		2304		1707		839		136		1275		404		1058	

[1] Liquid petroleum gas.
[2] Liquid natural gas.

b. Additional information on tankers is presented in Figure 3-6. Tankers up to about 200,000 dwt at design drafts of about 18.3 m (60 ft) are being brought into the deeper 15.2-m (50-ft) U.S. harbors at partial load in some cases.

c. The design ship is chosen as the maximum or near-maximum-size ship in the range of ship sizes from the vessel fleet. The design dimensions of the channel will be determined to accommodate the design ship(s) representative of the project forecasted user fleet. The channel width and depth need not be constant throughout the project but may vary as necessary so that the design ship will be able to make a safe, efficient, and cost-effective transit of the channel under the set of operational conditions chosen. Upon project authorization, the design dimensions are considered, nominally, to be the authorized dimensions. This should not preclude minor adjustments in width and depth during continued design, construction, and operation as circumstances warrant and delegated authorities permit.

3-12. <u>Design Transit Conditions.</u> The selection of the operational design conditions for the project is of major importance. The design ship should be able to make a safe transit while sailing through the proposed navigation channel under these design conditions. Extremes of weather, rare tidal or discharge events, and other limiting (though seldom encountered) conditions are not normally part of the design conditions. Some of the operational factors that have to be specified are:

a. Suitable current conditions.

b. Specified wind and wave conditions.

c. Visibility (day, night, fog, and haze).

d. Use of tidal advantage for additional water depth.

e. Traffic conditions (one- or two-way, pushtows, cross traffic).

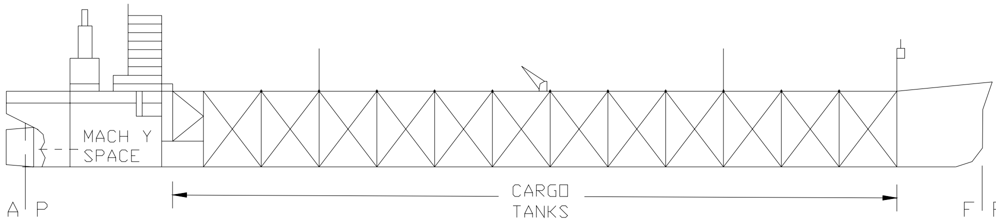
f. Speed restrictions.

g. Tugboat assistance.

h. Underkeel clearance.

The use of tidal advantage may establish ship transit periods during the tidal cycle, thus controlling tidal currents encountered by the ship. Normally, the design transit conditions should not consider extreme events that would limit or halt navigation traffic, such as hurricane winds or severe high tidal or flow currents. The inclusion of possible emergency events, such as engine failures, etc., should also be avoided, unless the channel is specifically to be designed to accommodate such operational circumstances. Normal operational conditions are strongly influenced by individual, local pilot, and pilot association rules and practices. Pilots will not usually move a ship through access channels to a terminal or dock for berthing if conditions and circumstances will not allow adequate tug assistance. There may be operational wind, wave, or current limitations on the ability to safely moor a ship at a terminal or berth, thus requiring a delay in ship transit. Turning operations and maneuvering into a side finger slip may set limitations on certain tidal height or current conditions. An important parameter is the wave height at a harbor entrance, which could prohibit a pilot boat from safely transferring the pilot onboard the ship.

Typical VLCC (Very Large Crude Carrier) Tanker



Length Overall	362.0 m (1187.5 ft)
Length Between Perpendiculars	348.4 m (1143.0 ft)
Length On Design Waterline	356.9 m (1171.0 ft)
Beam, Maximum Molded	69.5 m (228.0 ft)
Depth To Upper Deck At Side Molded	29.0 m (95.0 ft)
Draft, FUll Load Molded (Approx)	22.6 m (74.0 ft)
Displacement At Full Load Draft	450,910 Tons
Lightship	60,140 Tons
Total Deadweight	390,770 Tons
Shaft Horsepower	45,000
Sea Speed, Knots	15.9
Propeller 6 Blades, diam.	9.6 m (31.5 ft)

Ship Particulars For Example Tankers

	Amanda Miller	Sea Spirit	Jade	Nisseke Maru	Esso Atlantic
Length B.P., m (ft)	228.0 (748.0)	251.0 (843.2)	329.2 (1080.0)	330.0 (1082.7)	406.6 (1334.0)
Beam, m (ft)	32.2 (105.7)	40.8 (134.0)	51.8 (170.0)	54.5 (178.8)	71.0 (232.9)
Depth, m (ft)	17.5 (57.5)	21.3 (70.0)	25.6 (84.0)	35.0 (114.8)	31.2 (102.4)
Draft, m (ft)	13.2 (43.2)	16.0 (52.4)	20.1 (65.8)	27.0 (88.7)	25.0 (82.0)
VS, Knots	15.0	16.95	15.70	15.0	16.0
C_B	0.828	0.803	0.836	0.862	–
Froude Number	0.163	0.174	0.142	0.136	0.130
SHP	20,000	28,000	32,000 (M)	40,000	45,000
Propulsion	Diesel	steam	Steam	Steam	Steam
Light Ship, tons	15,060	19,700	33,150	52,150	–
Deadweight, tons	65,740	116,250	255,374	370,812	508,731
Displacement, tons	80,800	135,950	288,524	422,962	–
Length/Depth	13.009	12.046	12.858	9.428	13.032
Length/Beam	7.079	6.293	6.352	6.055	5.727

TANKER PARTICULARS

Figure 3-6. Tanker particulars (To convert tons to metric tons, multiply by 0.9072)